

## 5.0 NATURE AND EXTENT OF CONTAMINATION

### 5.1 SUSPECTED SOURCE AREA

The purpose of the remedial investigation (RI) was to provide additional information on the extent of VOC contamination in the groundwater and to investigate suspected contaminant sources identified by historical review of previous investigations. This investigation was not intended to fully characterize the potential sources, rather it was designed only to provide data on the potential sources of contamination and to assist with the identification of remedial alternatives. Further investigation may be performed during the remedial design/remedial action phase, if necessary. The source area monitoring wells installed and sampled during this phase of site investigation are shown in Figure 4-1.

#### 5.1.1 Soil

An intensive historical aerial photo study of the Newmark study area identified two suspected sources of groundwater contamination in the area: the Cat pit and the disposal trench. To evaluate these areas, five groundwater monitoring wells were drilled and core samples were collected following the procedures outlined in Section 3.2. The rationale for the location and subsequent sampling of the monitoring wells is described in Section 3.0.

Soil samples collected from the core barrel were analyzed by the EPA Region IX laboratory. Chemical detection results are summarized in Table 5-1 and Table 5-2. Complete soil analysis data tables are included in Appendix D. The results indicate that the suspected sources are probably not a current source of the contamination.

**Table 5-1**  
**Soil Sample Results**  
**Volatile Organics**  
**Detections Only**  
**Newmark Operable Unit RI/FS Report**

		Summary Detection Concentration (µg/Kg)		
		Methylene Chloride	Acetone	1, 2-Dichloroethane
Sample Number	Sample Depth (ft.)			
SMW02-05C	193.0 - 195.0	(11) 7 J		
SMW02-06C	195.0 - 197.0			(12) 2 J
SMW05-01C	69.0 - 70.0	(13) 3 j	(13) 18	

Notes: Sample specific quantitative limits are shown in parentheses.

Blanks indicate that the analute was not detected. Values followe by the qualifier J are estimated quantitiess and are useful for qualitative purposes only.

**Table 5-2**  
**Soil Sample Results**  
**Total Metals**  
**Detections Only**  
**Newmark Operable Unit RI/FS Report**

		Summary Detection Concentration (µg/L)																			
Sample Number	Sample Depth (ft.)	Aluminum (40.0)	Antimony (12.0)	Arsenic (2.0)	Barium (40.0)	Beryllium (1.0)	Cadmium (1.0)	Calcium (1000)	Chromium (2.0)	Cobalt (10.0)	Copper (5.0)	Iron (20.0)	Lead (0.6)	Magnesium (1000)	Manganese (3.0)	Nickel (8.0)	Potassium (1000)	Sodium (1000)	Thallium (2.0)	Vanadium (10.0)	Zinc (4.0)
SMW02-02C	20.0	4,680	9.4 J	1.0 J	25.5 J	0.19 J		2,330	6.3	3.6 J	7.6	7,510	2.8	2,630	128		1,020 J			13.3	18.7
SMW02-04C	72.0 - 74.0	3,490		0.68 J	18.0 J	0.19 J		4,340	5.0	2.5 J	7.5	7,320	2.7	2,120	134	4.9 J	503	379 J		11.0 J	15.3
SMW02-05C	193.0 - 195.0	15,000		1.4 J	65.6	0.64 J		4,170	23.9	10.8 J	21.1	25,600 J	4.5	7,750	248	14.1	4,170	179 J	0.19 J	54.5	48.7
SMW02-06C	195.0 - 197.5	13,700		0.59 J	58.0	0.49 J		3,920	25.9	10.5 J	16.6	19,600	3.9	6,990	217	15.7	4,050	202 J	0.19 J	41.0	45.6
SMW02-09C	202.0 - 204.5	15,100		6.5 J	58.8	0.51 J		4,760	32.3	9.7 J	11.8	18,700	3.9	7,430	218	12.7	4,520	156 J	0.18 J	37.0	44.2
SMW03-01C	71.0 - 71.5	3,480		0.37 J	20.4 J	0.21 J		2,640	5.1	2.7 J	10.2	5,840	3.2	1,850	133	3.9 J	608 J	249 J		9.5 J	14.3
SMW03-03C	148.0 - 150.0	6,340		0.88 J	45.3	0.25 J		4,690	9.2	5.6 J	16.8	10,100	3.5	3,720	210	8.1 J	1,300	154 J		16.9	22.9
SMW04-01C	70.0 - 71.0	9,340		0.73 J	103	0.34 J	2.9	4,890	9.7	9.2 J	15.7	17,900 J	3.9	6,800	279	7.8 J	3,370	315 J		35.2	41.8
SMW04-02C	70.0 - 71.0	9,280		1.5 J	52.9	0.36 J	2.7	3,770	15.7	8.3 J	11.2	14,000 J	2.9	5,270	218	11.3	2,740	187 J		28.0	36.8
SMW05-01C	69.0 - 70.0	6,070	0.87 J	47.9	0.25 J	2.0	6,640	9.8	5.1 J	10.0	10,900 J	4.7	4,710	254	9.8	1,120 J	224 J		16.5	27.9	
SMW05-03C	145.0 - 145.25	11,500	2.6	58.7	0.46 J	3.1	5,590	20.2	10.2 J	19.6	17,900 J	4.2	6,860	321	15.7	2,900	230 J	0.14 J	32.6	44.2	
SMW06-01C	20.0	4,580	0.44 J	23.6 J	0.16 J		4,270	7.0	5.2 J	11.5	7,560	1.9	2,890	159	10.1	1,030 J		0.13 J	12.9	18.5	
SMW06-02C	120.0 - 126.0	3,930	0.71 J	24.4 J	0.18 J		2,500	6.8	3.3 J	14.9	7,540	2.6	2,460	129	5.9 J	798 J	153 J		12.7	19.4	
SMW06-03C	129.0 - 135.0	5,130	0.64 J	26.8 J	0.24 J		5,510	8.2	4.4 J	11.4	8,440	3.0	2,910	153	8.8 J	963 J	185 J	0.14 J	14.3	19.6	
TTLC <sup>1</sup>		*	500	*500	10,000	75	100	*	500	8,000	2,500	*	1,000	*	*	2,000	*	*	700	2,400	5,000

Notes: Analyte specific detection limits are shown in parentheses. Blanks indicate that the analyte was not detected. Values followed by the qualifier J are estimated quantities and are useful for qualitative purposes only.

<sup>1</sup>Total threshold unit concentrations

\*Not established

## **Volatile Organic Compounds In Soil**

Table 5-1 presents the results of volatile organic compounds (VOCs) analyses of soil samples collected from monitoring wells MW02 through MW06 and two surface soil samples. Due to poor soil conditions, soil samples were not collected from MW07 or MW08 for laboratory analysis. Three VOCs (methylene chloride, acetone, and 1,2-dichloroethane) were detected. No TCE or PCE was detected in the soil samples analyzed from the suspected source area wells.

1,2-dichloroethane was detected at a concentration of 2  $\mu\text{g/Kg}$  in monitoring well MW02 at 195 feet bgs (soil sample SMW02-06C). The result is below the Contract Required Quantitation Limit (CRQL) and are estimated. The data were found to be qualitatively acceptable and valid for limited purposes.

Methylene chloride and acetone were detected. However, they are both commonly associated with laboratory contamination.

## **Metals**

Table 5-2 presents the results of metals analyses of soil samples collected from monitoring wells MW02 through MW06. Due to the limited scope of this focused RI/FS, a detailed investigation was not performed to establish background levels for metals in source area soil. However, a review of sample analytical results indicated that the detected levels of total metals in each sample were consistent with levels naturally found in this type of sediment. All of the detections were an order of magnitude less than the Total Threshold Limits Concentration (TTLC), as established by the State of California.

## **Pesticide/PCBs**

Soil samples collected from suspected source area monitoring wells and two surface soil samples were analyzed for pesticides and polychlorinated biphenyls (PCBs). These compounds were not detected in any of the samples analyzed from the monitoring well boring. Surface soil sample SSS01-01 collected

immediately south of monitor wells MW06A-JB in a field being prepared for subdivision detected levels of Dielchin at 1  $\mu$ /kg. These samples were collected because levels above ambient air background were recorded on a photo-ionization detector during the drilling of MW06A and B.

#### **Total Petroleum Hydrocarbon**

Soil samples collected from monitoring wells MW02 through MW06 were analyzed for Total Petroleum Hydrocarbons (TPH) as gasoline and diesel. TPH as gasoline or diesel was not detected in any of the soil samples analyzed.

#### **5.1.2 Groundwater**

Appendix E lists the constituents analyzed by the EPA Region IX laboratory in groundwater. For reference, Appendix O contains the drillers logs and historical data results from municipal wells samples during this investigation. The methodologies used for analysis, and additional Quality Assurance (QA) procedures used for sampling, are outlined in Section 3.0. Detection results of groundwater samples collected from source area monitoring wells are summarized in Tables 5-3, 5-4, and 5-5; all laboratory analytical data is contained in Appendix E. The United States EPA has established Maximum Contaminant Levels (MCLs) for many VOCs. These MCLs, when available, were used for comparison throughout this section.

#### **Volatile Organic Compounds**

Groundwater samples were collected from all newly installed monitoring wells in the suspected source area (MW02 through MW08). VOCs were found in all wells except MW06. Detected compounds are summarized in Table 5-3. Detections below CRQLs are qualified J and are usable for qualitative purposes only.

Tetrachloroethene, or perchloroethylene (PCE), was detected in MW02A/B, MW03A/B, MW04B, MW05A/B, MW07A/B, and MW08A/B. PCE is the contaminant most frequently detected during this investigation. Contamination ranged from nondetect in well MW04A and MW06A/B to 25  $\mu$ g/L in well

**Table 5-3**  
**Groundwater Sample Results**  
**Volatile Organics**  
**Detections Only**  
**Newmark Operable Unit RI/FS Report**

Sample Number	Summary Detection Concentration (µg/L)												
	Methylene Chloride (2)	1, 1 Dichloroethane (2)	cis-1, 2 Dichloroethene (2)	Chloroform (2)	1, 1, 1-Trichloroethane (2)	1, 2-Dichloropropane (2)	Trichloroethene (2)	Tetrachloroethene (2)	Toluene (2)	Carbon Tetrachloride (2)	Dichlorofluoromethane <sup>1</sup>	Trichlorofluoromethane <sup>1</sup>	Butene
WMW01A-01C									0.4 J				
WMW01D-01C									0.2 J				
WMW01E-01C									0.3 J				
WMW01G-01C									0.2 J				
WMW01G-02C									0.3 J				
WMW01H-01C									0.4 J				2 J
WMW01I-01C									0.4 J				1 J
WMW01J-01C									0.3 J				2 J
WMW02A-01C								0.3 J					
WMW02B-01C		0.6 J	2				3	16			5 J	8 J	
WMW02B-02C <sup>2</sup>		0.6 J	2				3	16			5 J	9 J	
WMW03A-01C								0.2 J					
WMW03B-01C	0.2 J	0.9 J		0.2 J			4	19				11 J	
WMW03B-02C <sup>2</sup>	0.2 J	0.9 J	2	0.2 J			4	19			4 J	11 J	
WMW04B-01C		0.3 J	0.6 J			2 J	1 J	10			2 J	5 J	
WMW05A-01C								0.4 J					
WMW05B-01C		1 J	3	0.2 J	0.2 J	0.2 J	6	22			5 J	12 J	
WMW07A-01C	0.2 J	0.7 J	3				4	16		0.3 J	7 J	5 J	
WMW07B-01C		0.6 J	0.8 J				3	16			7 J	8 J	
WMW07B-02C		0.6 J	0.8 J				3	16			7 J	7 J	
WMW08A-01C								0.3 J		0.7 J			
WMW08B-01C	0.2 J	0.7 J	3				3	25	1000		6 J	7 J	
Maximum Contaminant Levels (MCLs)	*	5	6	100	200	5	5	5		0.5	*	150	

Notes: Sample specific quantitation limits are shown in parentheses. Blanks indicate that the analyte was not detected. Values followed by the qualifier J are estimated quantities and useful for qualitative purposes only.

<sup>1</sup>Tentatively identified compounds    <sup>2</sup>02 is a duplicate    \*No MCL yet established

**Table 5-4**  
**Groundwater Sample Results**  
**Total Metals**  
**Detections Only**  
**Newmark Operable Unit RI/FS Report**

Sample Number	Summary Detection Concentration (µg/L)																		
	Aluminum (200)	Arsenic (10)	Barium (60)	Calcium (5000)	Chromium (10)	Cobalt	Copper (25)	Iron (100)	Lead (3.0)	Magnesium (5000)	Manganese (15)	Mercury (0.2)	Nickel (40)	Potassium (5000)	Selenium	Sodium (5000)	Thallium	Vanadium (50)	Zinc (20)
WMW01A-01C <sup>1</sup>			45.5 J	83,600	3.8 J			923		15,600	27.5			3,630 J	3.8 J	24,800	6.8 J		14.3 J
WMW01B-01C			47.5 J	86,800	4.8 J			447		14,800	13.4 J			3,400 J		17,900		3.3 J	8.4 J
WMW01C-01C			47.4 J	81,500	4.2 J			455	1.0 J	14,900	16.8			3,270 J		17,900		3.9 J	11.4 J
WMW01D-01C			49.3 J	85,400	4.2 J			533		15,600	23.4			3,690 J		18,800		3.3 J	11.9 J
WMW01E-01C			47.5 J	83,600	5.0 J			542		15,300	26.5			3,620 J		18,500	1.2 J		10.4 J
WMW01F-01C			51.1 J	90,100	5.4 J	4.3 J		836		16,500	40.6			3,980 J	4.5 J	19,900	1.9 J	4.5 J	27.3 J
WMW01G-01C			46.7 J	84,800	4.9			906		15,600	46.7			3,400 J	3.9 J	19,100	1.1 J	3.9 J	27.2
WMW01G-02C <sup>1</sup>			47.5 J	86,200	6.8 J			927		15,800	47.8			3,630 J		19,400			79.1
WMW01H-01C			40.7 J	79,100	7.6 J			1,150		14,800	82.8			3,170		18,200			15.3 J
WMW01I-01C			36.0 J	75,400	5.2 J			1,830		14,700	141			3,250 J		18,200			16.0 J
WMW01J-01C			38.6 J	78,400	93.2			4,140		17,300	349			4,040 J		35,900	3.5 J		59.8
WMW02A-01C	115 J		62.5 J	78,600	8.3 J			12,200	2.1 J	15,500	273	0.2 J		3,170		19,200			1,060
WMW02B-01C	464		64.6 J	87,900	5.4 J			9,640	1.6 J	17,800	172 J		14.2 J	4,860		18,600			568
WMW02B-02C <sup>1</sup>	773		69.0 J	88,100	7.1 J			10,000	3.9 J	17,900	165	0.2 J		4,760 J		18,500			562
WMW03A-01C	5,880	2.0 J	60.4 J	57,500	21.4		13.4 J	28,400	10.0 J	17,900	340		17.4 J	7,880		52,500		10.3 J	1,330
WMW03B-01C	2,300 J	1.3 J	70.2 J	76,400	11.9			4,210	4.7 J	18,100	121			7,110		45,700			190
WMW04A-01C	220 J	2.0 J	35.7 J	64,600	11.9			4,670		13,600	91.1			3,880 J		23,900			588
WMW04B-01C	144 J		37.2 J	72,400	4.1 J			570		15,700	47.4			4,680 J		19,700			389
WMW05A-01C	5,180 J	1.8 J	61.4 J	43,400	16.4		10.4 J	20,000	10.6	10,200	341		17.6 J	6,380		19,800		9.8 J	358
WMW05B-01C	301 J		45.2 J	81,500	4.2 J			3,250	1.6 J	16,500	110			5,180		15,800			108
WMW06A-01C			41.7 J	76,500				52,600	1.2	16,200	428		19.7 J	2,490 J		17,000			545
WMW06B-01C	2,670 J		54.9 J	72,700	9.3 J		4.6 J	5,480	2.5 J	17,000	109			3,190 J		23,300			498
MCLs	1000	50	1000	*			*	*	50	*	*	2	100	*		*		*	*

Notes: Sample specific detection limits are shown in parentheses. Values followed by the qualifier J are estimated quantities and useful for qualitative purposes only. Blanks indicate that the analyte was not detected.  
<sup>1</sup>-02 is a duplicate sample      \* No MCL established

**Table 5-5**  
**Municipal Water/Cal EPA Monitoring Well**  
**Sample Results**  
**Detections Only**  
**Newmark Operable Unit RI/FS Report**

City Well Names	URS Well #	Summary Detection Concentrations (µg/L)								
		Methylene Chloride (2)	1, 1 Dichloroethane (2)	cis 1, 2 Dichloroethane (2)	Chloroform (2)	1,2 Dichloropropane (2)	TCE (2)	PCE (2)	Dichlorofluoromethane <sup>1</sup>	Trichlorofluoromethane <sup>1</sup>
Newmark #4	Muni 03		0.5 J	0.9 J			2	12	3 J	5 J
Newmark #1	Muni 05		0.4 J	0.8 J			2	9	2 J	3 J
Newmark #3	Muni 06		0.4 J	1 J			2	15	3 J	6 J
Electric Ave. #1 W1-1	Muni 08				0.5 J					
Electric Ave. #2 W2-3	Muni 09	0.3 J	0.9 J	1 J	0.2 J		5	22	5 J	10 J
Parkdale Schl. W3-2	Muni 11	0.4 J	1 J	2	0.3 J	0.2 J	7	32	5 J	10 J
Parkdale Schl. W3-3	Muni 12	0.3 J	0.4 J	1 J			3	15	2 J	5 J
Waterman Ave.	Muni 13		0.6 J	1 J			4	21	5 J	12 J
31st. St. & Mt. View	Muni 14		0.6 J	1 J			5	20	5 J	15 J
30th. St. & Mt. View	Muni 15	0.2 J	0.4 J	1 J			5	18	5 J	13 J
Leroy	Muni 16		1 J	2	0.3 J	0.2 J	7	36	10 J	30 J
27th St.	Muni 18	0.3 J		0.3 J			0.2 J	0.5 J		
North E St.	Muni 19						0.4 J	0.7 J		
23rd. St.	Muni 20							0.3 J		
17th. St.	Muni 22			0.2 J			2	3	2 J	2 J
16th. St.	Muni 23						2	3	1 J	2 J

Notes: Sample specific quantification limits are shown in parentheses.  
 Values followed by the qualifier J are estimated quantities and are useful for qualitative purposes only.  
 Blanks indicate that the analyte was not detected.

<sup>1</sup> Tentatively identified compounds



MW08B. Caution should be exercised in evaluating the data from MW08B due to elevated levels of turbidity. This well should probably be resampled to confirm this concentration. PCE MCL (5 µg/L) was exceeded in: MW02B, MW03B, MW04B, MW05B, MW07A/B, and MW08B.

Trichloroethene (TCE) was detected in MW02B, MW03B, MW04B, MW05B, MW07A/B, and MW08B. Contaminants ranged from nondetect in well MW03A to a high of 6 µg/L in MW05B. TCE MCL (5 µg/L) was exceeded in MW05B only.

Cis-1,2-dichloroethene was detected in MW02B, MW03B, MW04B, MW05B, MW07A/B, and MW08B. Levels of contamination ranged from nondetect to 3.0 µg/L. Detection was above the CRQL in MW05B, MW07A, and MW08B, but no detections exceeded the established MCL (6 µg/L) for the compound.

1,1-dichloroethane was detected in MW02B, MW03B, MW04B, MW05B, MW07A/B, and MW08B. Concentrations ranged from nondetect to 1 µg/L. Detected concentrations were below the CRQL and did not exceed the established MCL (5 µg/L) for the compound.

Carbon tetrachloride was detected in MW07A at an estimated value of 0.3 µg/L and in MW08A at 0.7 µg/L. Carbon tetrachloride has historically never been a constituent of concern at the site. Detected concentrations were below the CRQL, but the MW08A sample estimated value may have exceeded the MCL (0.5 µg/L) established for the compound.

The data were "J" qualified indicating their suitability as an estimate only. To better quantify the carbon tetrachloride concentration it is suggested that the well be re-sampled and analyzed using EPA Method 524.2 which has a CRQL of 0.5 µg/L.

Additional VOC compounds which were detected included: methylene chloride (MW03A, MW07A, MW08B), chloroform (MW03B, MW05B); 1,2-dichloropropane (MW04B, MW05B); and 1,1,1-trichloroethane (MW05B). All of these compounds were found in concentrations of 0.2 µg/L below the CRQL and the established MCL for each compound.

Tentatively identified compounds (TICs) detected in groundwater samples include dichlorofluoromethane and trichlorofluoromethane. Dichlorofluoromethane was detected in MW07A/B at 7  $\mu\text{g/L}$ . Trichlorofluoromethane was detected in MW07A at 5  $\mu\text{g/L}$  and in MW07B at 8  $\mu\text{g/L}$ . These compounds were outside the normal list of identified compounds for the laboratory procedures used, so no CRQL was established. Trichlorofluoromethane was detected at concentrations below the established MCL (150  $\mu\text{g/L}$ ). No MCL has been established for dichlorofluoromethane.

Two additional TICs were detected by the laboratory during analysis. Both were detected at concentrations estimated to be on the order of 1  $\mu\text{g/L}$ . The laboratory was unable to identify either compound.

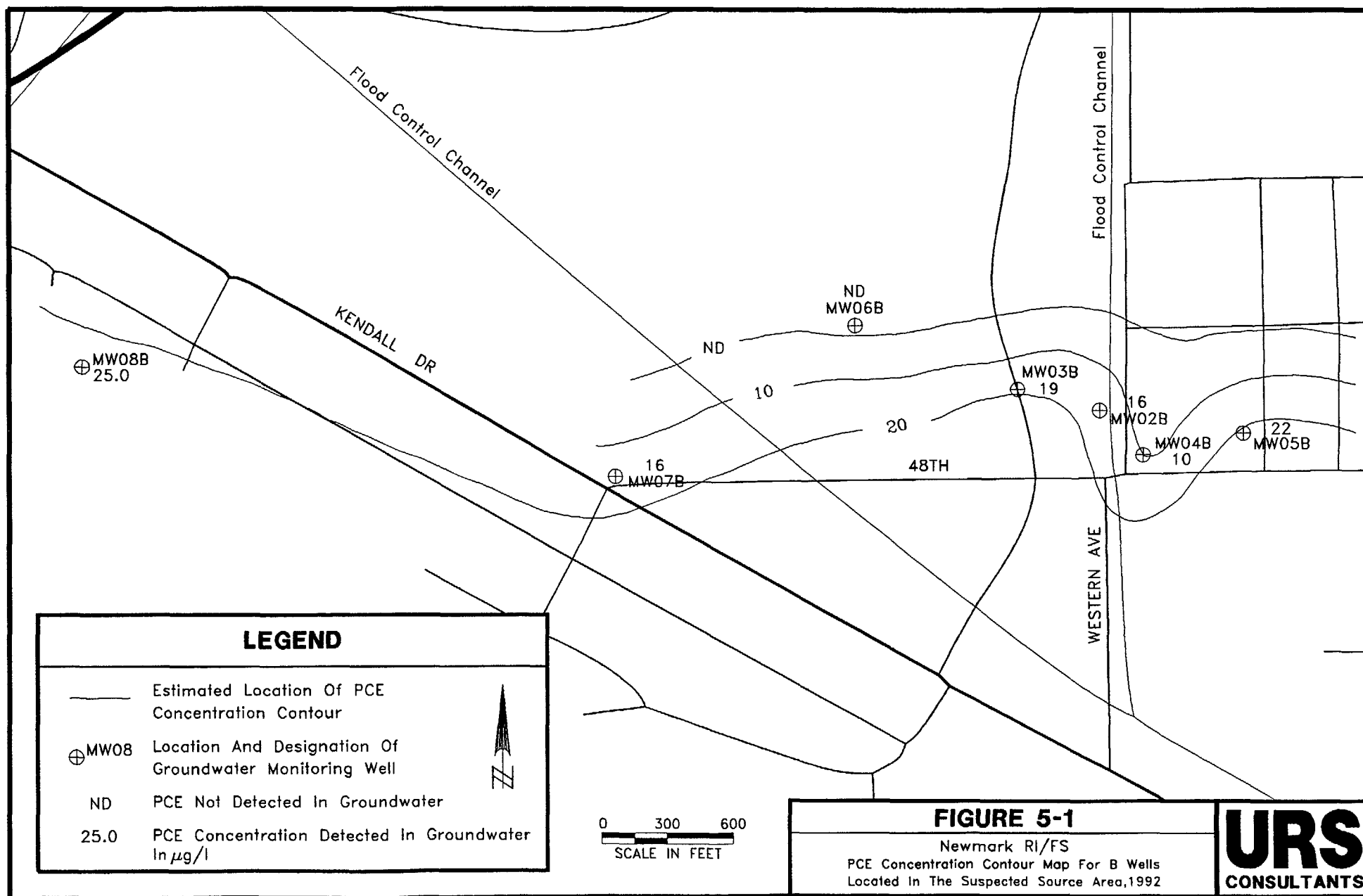
In general, the highest concentrations of both TCE and PCE were found in the deeper B wells. Both TCE and PCE have a higher specific gravities than water. They tend to sink to the bottom of the aquifer, where they will flow to the lowest point of the impermeable aquitard. Concentration contours, generated from the most recent sampling data (Figure 5-1), appear parallel to the groundwater flow. Contaminant values were also found to be higher in the upgradient wells; signifying that a source is possibly located upgradient of the investigation area.

#### **Semivolatile Organic Compounds**

All water samples collected from source area monitoring wells MW02 through MW06 were analyzed for semivolatile organic compounds. These compounds were not detected in any of the samples analyzed.

#### **Metals**

A summary of metal concentrations from monitoring wells installed in the San Bernardino area are presented in Table 5-4. These results are from a one time sampling effort. Groundwater samples collected from source area monitoring wells MW02A/B through MW06A/B were analyzed for total



metals. Groundwater samples from MW07A/B and MW08A/B were not analyzed for total metals. A summary of detections is presented in Table 5-4.

Results for arsenic, barium, cobalt, copper, mercury, nickel, selenium, thallium, and vanadium were all either non-detect or are an estimate and used for limited purposes only. Laboratory results indicated that aluminum and chromium were the only metals detected at levels exceeding the MCL (1,000 M and 50 µg/L, respectively) for drinking water. The MCL for aluminum was exceeded in samples from MW03A, MW03B, MW05A and MW06B (Table 5-4). The MCL for chromium was exceeded in the sample from MW01.

The Bentonize based drilling mud used during drilling, the pulverized native materials, and construction materials such as the Bensen sealant, may have contributed to elevated levels of metals found in the analytical samples from the newly installed monitoring wells. The fluid used to drill all suspected source area monitoring wells is composed of a clay mineral called bentonite. Bentonite is a member of the montmorillonite clay group. A typical montmorillonite clay has a chemical composition of:  $Al_4Si_8O_{20}(OH)_4 \cdot nH_2O$ . It is possible that very fine grained particles of the bentonite drilling fluid (introduced into the aquifer during drilling operations) were suspended in the groundwater samples submitted to the laboratory for analysis. Additionally the native materials the wells were installed in contain significant levels of aluminum. Therefore, the elevated aluminum levels detected might have been caused by the drilling process and are not representative of groundwater quality in the area.

The stainless steel casing that was used in the construction of the wells is known to contain chromium and may have contributed to the elevated levels of chromium found in the analytical sample from MW01. It is possible that very fine grained particles of stainless steel from the casing (introduced during well installation) were entrained in the groundwater samples submitted to the laboratory for analysis. The elevated aluminum levels detected might have been caused by materials introduced into the aquifer water during the drilling process and are not representative of groundwater quality in the area. The monitoring wells that exceeded MCL's for aluminum and chromium were in the vicinity of municipal wells which have yet not recorded the presence of these metals above the MCL's.

1 In summary, elevated concentrations of aluminum and chromium are considered to be artifacts of the  
2 construction and subsequent development of the monitoring wells. Any concern over these concentrations  
3 should be addressed through additional rounds of future water quality sampling.

#### 4 **Municipal Wells**

5 Metal concentrations from municipal wells in the San Bernardino area are presented in Appendix D. The  
6 detection limits used for these sampling events have been set below the secondary maximum contaminant  
7 levels by the State of California to detect metal concentrations that could negatively affect public health.  
8 These detection limits in general are higher than those used for monitoring wells.

9 In all cases with the exception of one sample taken from the 17th Street number 2 well, concentrations  
10 of metals were all below detection. Iron was detected at 701  $\mu\text{g/L}$  in the 17th Street well. This value  
11 is attributed to the fact that the well was recently installed using a steel casing.

12 Cation data from municipal wells in the plume area (municipal wells 3-6, 13-16, 18-20, 22 and 23, total  
13 samples = 12) was statistically compared versus cation data from municipal wells outside of the plume  
14 area (municipal wells 1, 2, 17, 21, 25 and 26, total samples = 6). Results show that there is not a  
15 statistically significant difference at one standard deviation between the two groups for magnesium,  
16 potassium or sodium. Results for calcium show a significant difference, however, the small number of  
17 samples available for analysis cast doubt on the validity of this result.

#### 18 **Other Constituents**

19 Groundwater samples collected from source area monitoring wells were also analyzed for pesticides,  
20 PCBs, and Total Petroleum Hydrocarbons (gasoline and diesel). These compounds were not detected in  
21 any of the source area groundwater samples.

## 5.2 PLUME AREA

The municipal wells and monitoring wells installed during previous studies within the investigation area and MW01 were sampled and analyzed for VOAs. The locations of wells sampled are depicted on Plate 1. Two categories of wells were sampled: wells previously analyzed and found to be contaminated and wells located outside the known or projected plume boundary (up-, down-, or cross-gradient). Results from the first category of wells were used to verify previous sample results and suspected location of the plume boundaries. Results from the second category of wells were used to better delineate the estimated extent of the plume. Additionally, monitoring well MW01 was installed and sampled to aid in characterizing the vertical distribution of contaminants in the known plume.

Twenty-six wells were sampled and analyzed for VOAs with EPA Method 624 with a lowered quantitation limit as necessary for comparison with drinking water standards (see Section 3.7). Seven of the wells were being pumped as part of the City's water supply system. These wells are the four Newmark Wellfield wells, Waterman Avenue well, and 16th Street and 17th Street wells. The other municipal wells were pumped a minimum of 1/2 hour prior to sampling. Complete sample results are provided in Appendix E. Results for detected compounds for each well are shown on Table 5-5. Historical results for the municipal wells that exceeded MCLs for TCE and PCE are shown on Table 5-6. The most frequently detected contaminants within the plume were TCE and PCE. Other contaminants present in varying concentrations throughout the plume included methylene chloride, 1,1-dichloroethene, cis-1,2-dichloroethene, chloroform, 1,2-dichloropropane, dichlorofluoromethane and trichlorofluoromethane.

**Table 5-6**  
**MUNICIPAL WELLS**  
**SAMPLING RESULTS FOR TCE AND PCE**  
**1980 - 1992**  
**(µg/L)**

YEAR/ QTR	NEWMARK #1		NEWMARK #2		NEWMARK #3		NEWMARK #4		LEROY		WATERMAN AVENUE		30TH & MT. VIEW		31ST & MT. VIEW	
	TCE	PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE	PCE
1980/ 2	NA	NA	0.26	0.51	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980/ 3	1.30	9.40	0.54	0.80	5.00	19.00	<0.25	<0.25	4.60	8.20	1.20	2.70	4.70	6.30	6.90	8.20
1980/ 4	1.10	4.10	NA	NA	4.40	19.00	NA	NA	NA	NA	NA	NA	3.60	4.70	4.80	7.40
1981/ 3	3.00	16.00	NA	NA	4.30	21.00	NA	NA	2.90	5.60	1.00	1.70	3.50	5.60	NA	NA
1981/ 4	NA	NA	0.60	1.70	5.30	29.00	NA	NA	NA	NA	NA	NA	NA	NA	3.00	5.30
1982/ 3	4.20	31.00	0.10	0.10	7.20	41.00	<0.10	<0.10	4.70	11.00	2.40	4.40	2.80	4.80	4.20	7.60
1983/ 1	2.70	13.70	0.20	1.10	10.00	51.00	0.88	0.51	3.80	7.80	1.30	<0.50	4.50	6.40	3.80	6.40
1983/ 3	5.70	42.00	0.29	2.40	12.00	73.00	<0.10	<0.10	0.70	2.60	NA	NA	3.00	5.90	2.50	4.30
1983/ 4	3.30	22.40	0.20	0.20	NA	NA	<0.20	<0.20	1.60	7.50	NA	NA	2.20	6.00	2.70	5.80
1984/ 1	2.00	18.00	NA	NA	15.50	78.00	<0.20	<0.20	NA	NA	NA	NA	NA	NA	NA	NA
1984/ 3	1.70	7.70	1.00	1.00	6.60	37.50	1.60	9.60	<1.00	4.80	<1.00	<1.00	2.50	5.10	2.40	4.90
1984/ 4	3.90	25.00	1.10	7.40	12.00	70.00	4.80	28.00	1.50	6.50	NA	NA	2.10	3.70	2.90	3.20
1985/ 1	20.50	144.90	3.50	23.80	17.00	123.40	10.00	52.00	2.50	11.00	1.90	4.10	2.60	4.40	3.40	3.70
1985/ 2	6.20	68.10	2.60	14.10	1.60	64.20	11.00	64.10	2.00	21.50	<0.20	0.40	1.20	2.90	2.30	3.90
1985/ 3	13.90	55.30	2.50	15.70	NA	NA	9.40	116.00	2.90	19.40	2.30	5.30	4.30	6.60	4.20	7.30

Table 5-6 (Cont'd.)

**MUNICIPAL WELLS  
SAMPLING RESULTS FOR TCE AND PCE  
1980 - 1992  
(µg/L)**

YEAR/ QTR	NEWMARK #1		NEWMARK #2		NEWMARK #3		NEWMARK #4		LEROY		WATERMAN AVENUE		30TH & MT. VIEW		31ST & MT. VIEW	
	TCE	PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE	PCE
1985/ 4	18.40	48.40	4.50	19.50	17.50	48.00	23.00	50.30	4.00	15.70	2.60	9.00	4.50	5.60	4.50	9.30
1986/ 1	17.40	125.00	5.90	29.90	14.70	152.00	27.40	166.00	5.30	34.60	1.00	1.60	4.20	4.70	2.80	5.50
1986/ 2	18.80	145.00	6.50	18.80	16.90	165.00	28.40	136.00	4.20	29.20	0.80	1.20	3.90	5.70	3.20	8.40
1986/ 3	NA	NA	NA	NA	12.50	57.00	NA	NA	6.20	20.50	<0.10	<0.10	3.60	5.20	3.60	7.90
1986/ 4	16.00	89.00	4.10	21.00	11.00	76.00	19.00	101.00	6.10	28.00	1.30	5.70	3.40	6.20	5.20	7.90
1987/ 1	NA	NA	5.20	26.70	21.60	135.60	24.60	98.00	7.80	23.30	0.20	1.20	5.00	8.00	5.20	9.70
1987/ 2	NA	NA	NA	NA	NA	NA	36.80	108.60	NA	NA	NA	NA	NA	NA	NA	NA
1987/ 3	NA	NA	NA	NA	11.30	71.80	NA	NA	5.90	25.70	3.20	16.30	5.10	10.00	NA	NA
1987/ 4	12.00	64.90	4.00	24.10	8.90	63.10	14.20	89.40	9.10	48.30	1.00	3.70	4.10	7.40	3.00	8.80
1988/ 1	10.60	73.20	7.30	30.10	NA	NA	12.60	81.60	8.70	42.80	1.20	3.30	4.60	4.10	3.60	9.90
1988/ 2	3.40	38.00	<0.50	1.70	8.20	61.40	5.60	42.00	8.20	43.50	2.60	6.50	3.30	6.70	<0.50	9.60
1988/ 3	0.50	15.30	<0.50	2.80	4.80	45.30	7.60	55.90	10.80	54.10	NA	NA	4.00	11.10	3.20	14.50
1988/ 4	<0.50	1.30	5.20	38.90	6.80	50.50	10.00	73.10	NA	NA	NA	NA	NA	NA	NA	NA



Table 5-6 (Cont'd.)

**MUNICIPAL WELLS  
SAMPLING RESULTS FOR TCE AND PCE  
1980 - 1992  
(µg/L)**

YEAR/ QTR	NEWMARK #1		NEWMARK #2		NEWMARK #3		NEWMARK #4		LEROY		WATERMAN AVENUE		30TH & MT. VIEW		31ST & MT. VIEW	
	TCE	PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE	PCE
1989/ 1	4.20	41.50	<0.50	3.30	NA	NA	NA	NA	10.90	57.30	NA	NA	4.40	12.40	3.80	14.90
1992/ 1	2.0	9.0	<2.0	<2.0	2.0	15.0	2.0	12.0	7.0	36.0	4.0	21.0	5.0	18.0	5.0	20.0

\* = Highest contaminant value recorded per quarter. Quarters not represented in this table indicate sample results were not analyzed.  
NA = Not analyzed.

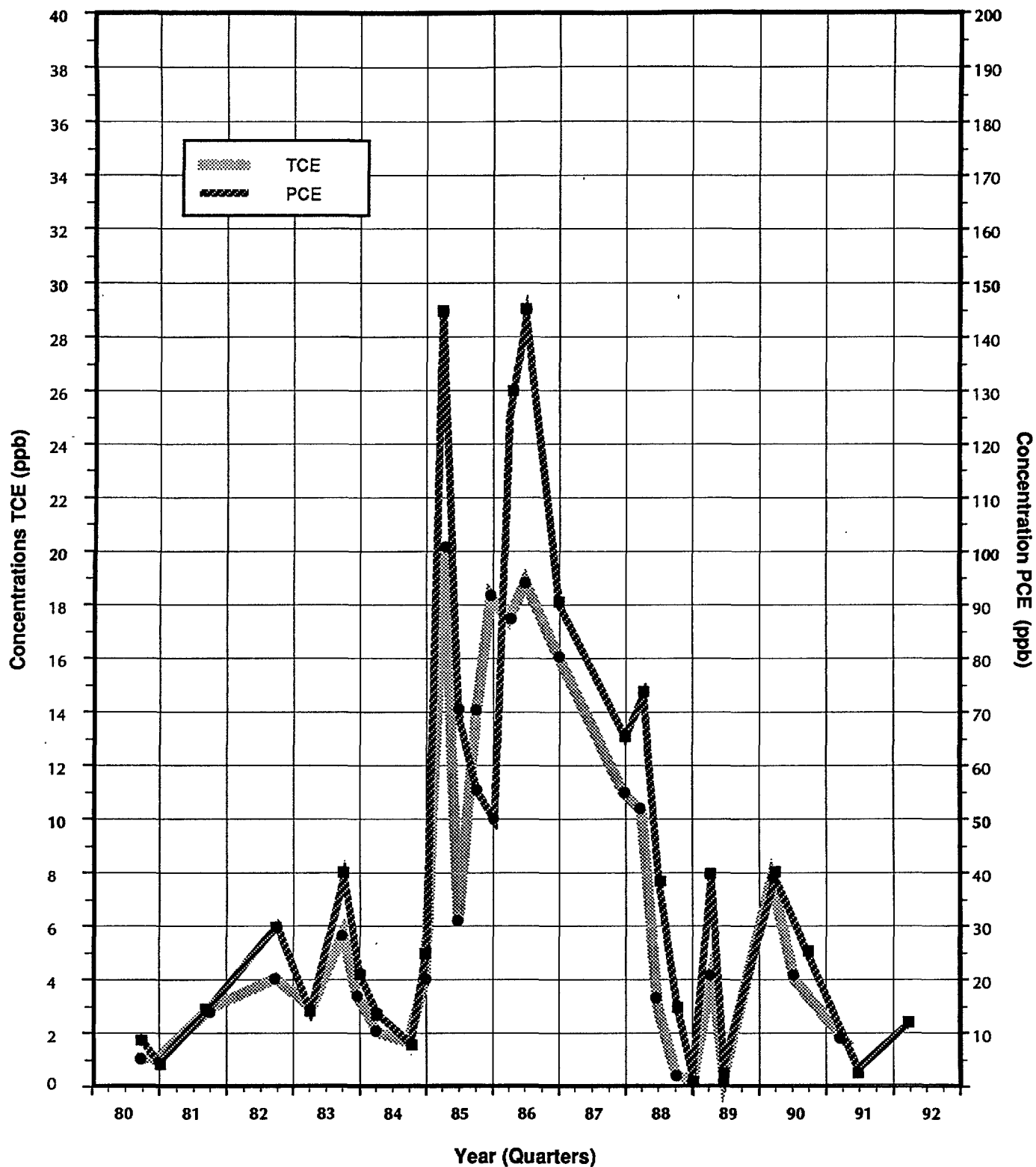
Source: City of San Bernardino Water Department Water Quality Information (1980 - 1992)  
North San Bernardino Preliminary Assessment/Site Inspection (E&E 1989)  
URS Municipal Well Sample Results - March 1992

No contaminants were detected in the two municipal wells, Devil Canyon #1 and #2, located about 1.5 miles upgradient from the Newmark Wellfield. Within the Newmark Wellfield, Newmark #2 also had no contaminants detected. Newmark #1, #3 and #4 each had 2 µg/L of TCE and 9, 15 and 12 µg/L of PCE, respectively. Other compounds detected at concentrations below the quantitation limit included DCA, DCE, Freon 11, and Freon 12 in Newmark #1, #3, and #4. Newmark #2 for the past 12 years has had lower concentrations of contaminants than the other Newmark Wellfield wells and had no detection of TCE in 1988 or 1989. The concentration of contaminants in the remaining three Newmark Wellfield wells decreased since the mid-1980s (Table 5-6).

Three monitoring well clusters were installed approximately 1.5 to 2 miles southeast of the Newmark Wellfield. Sampling results from these wells are as follows: Electric Drive W1-1 (MUNI 08), screened depth 236 to 246 feet bgs, contained 0.5 µg/L Chloroform; Electric Drive #2 W2-3 (MUNI 09) contained 0.5 µg/L TCE and 22 µg/L PCE; Parkdale School (MUNI 11), intermediate-screened depth 300 to 360 feet bgs, contained 7 µg/L TCE and 32 µg/L PCE; Parkdale School (MUNI 12), deep-screened depth 492 to 502 feet bgs, contained 3 µg/L TCE and 15 µg/L PCE.

#### **Center of Plume**

In the central part of the plume (see Figure 1-4), the Waterman Avenue and Leroy wells and the 31st and Mountain View and 30th and Mountain View wells had similar concentrations of contaminants. TCE ranged from 4 to 7 µg/L and PCE ranged from 18 to 36 µg/L with the highest concentration in the Leroy well. Other compounds detected at minor concentrations in all four wells included DCA (Freon 11), and DCE (Freon 12). The concentrations in the Leroy well were down slightly from the highest concentrations found in 1989, while the concentrations in the Waterman Avenue well were the highest recorded. The concentrations in the 30th and 31st and Mountain View wells had little fluctuation during the past twelve years, although PCE concentrations from this sampling period were the highest historically. Table 5-6 details historical sampling results from these eight wells, with Figures 5-2 through 5-9 providing graphic representation, useful in analyzing trends.



**Figure 5-2**  
**Municipal Well Sampling Results for TCE & PCE**  
**Newmark Wellfield #1**  
**Newmark Operable Unit RI/FS Report**

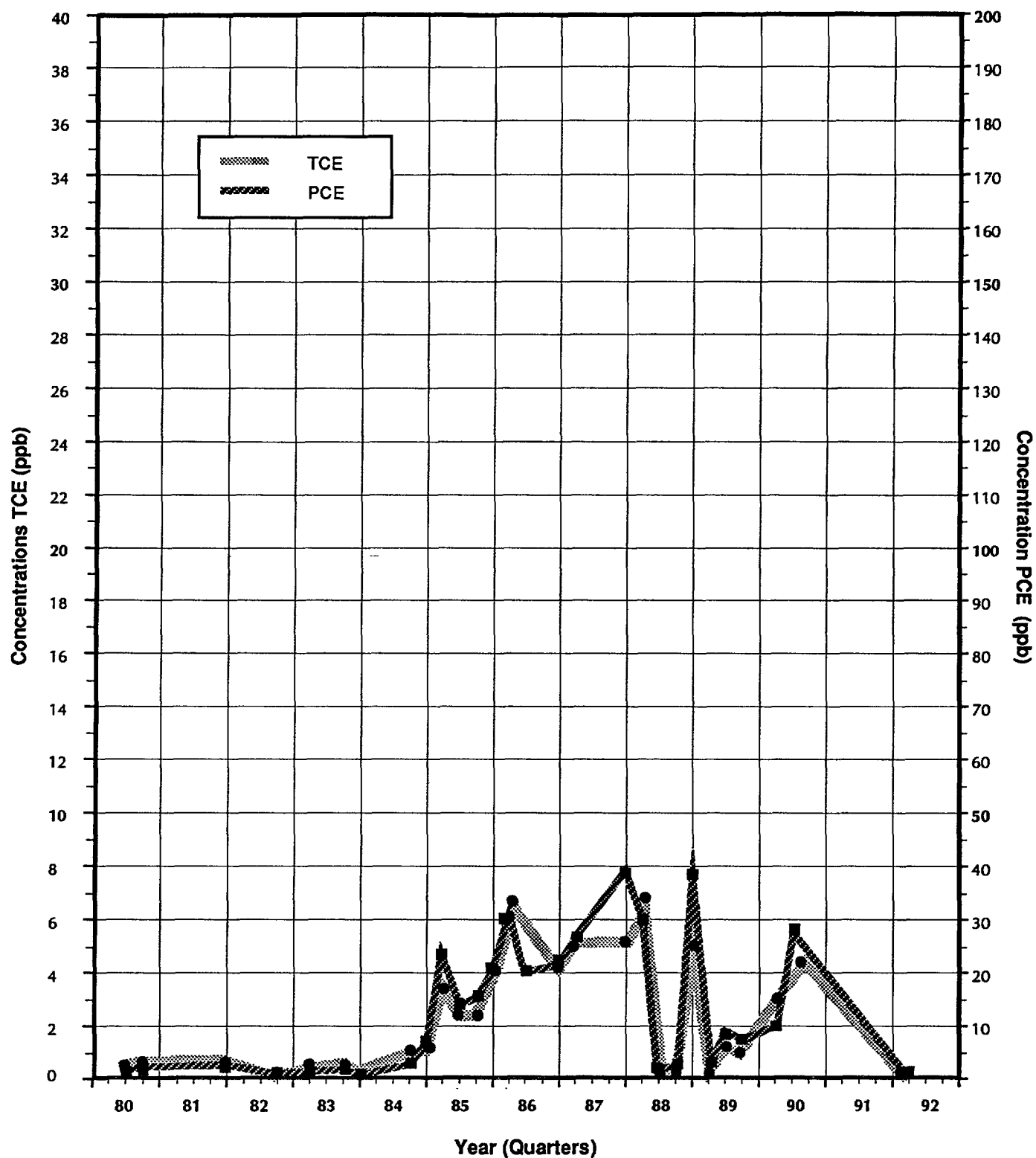


Figure 5-3  
Municipal Well Sampling Results for TCE & PCE  
Newmark Wellfield #2  
Newmark Operable Unit RI/FS Report

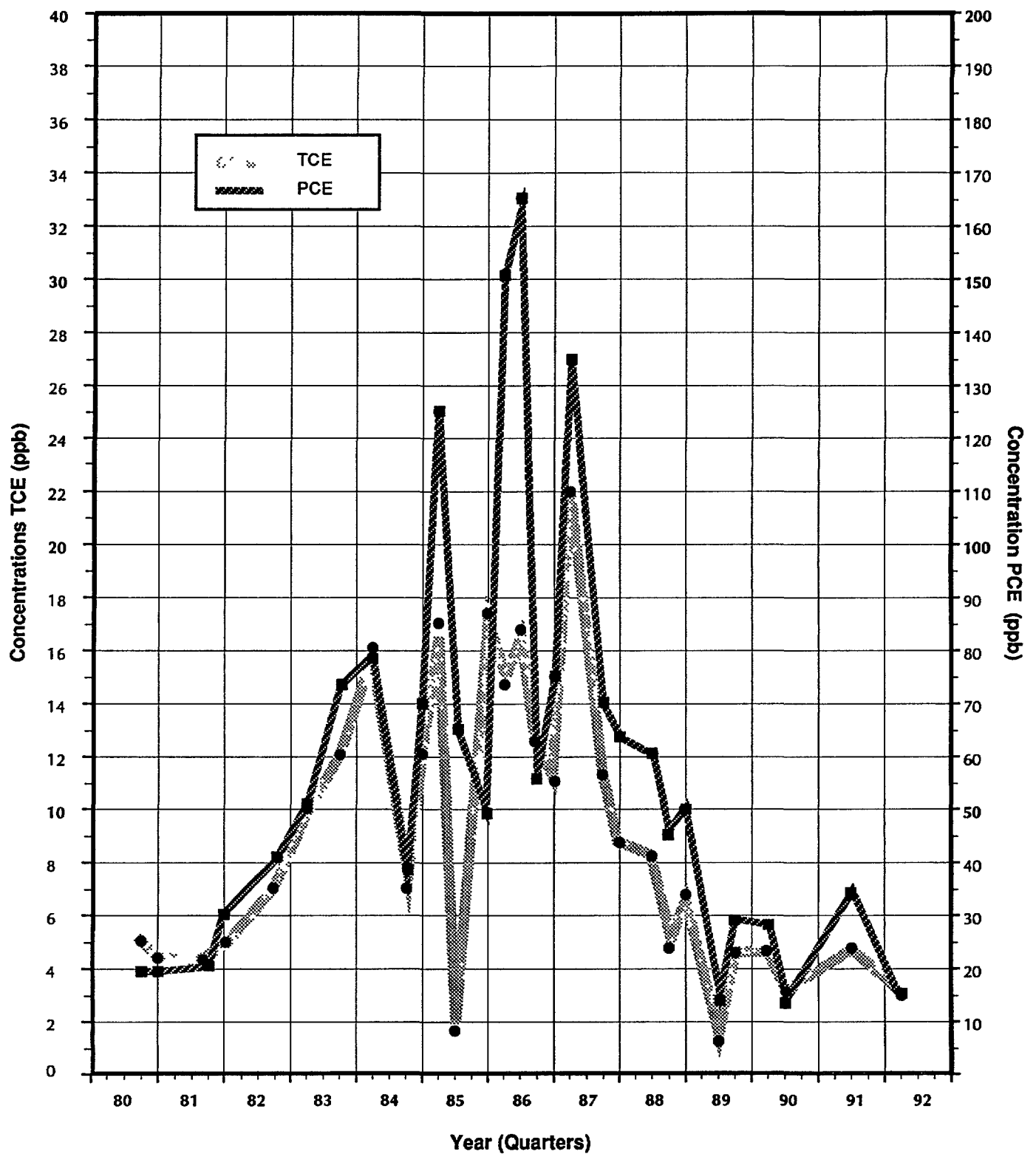
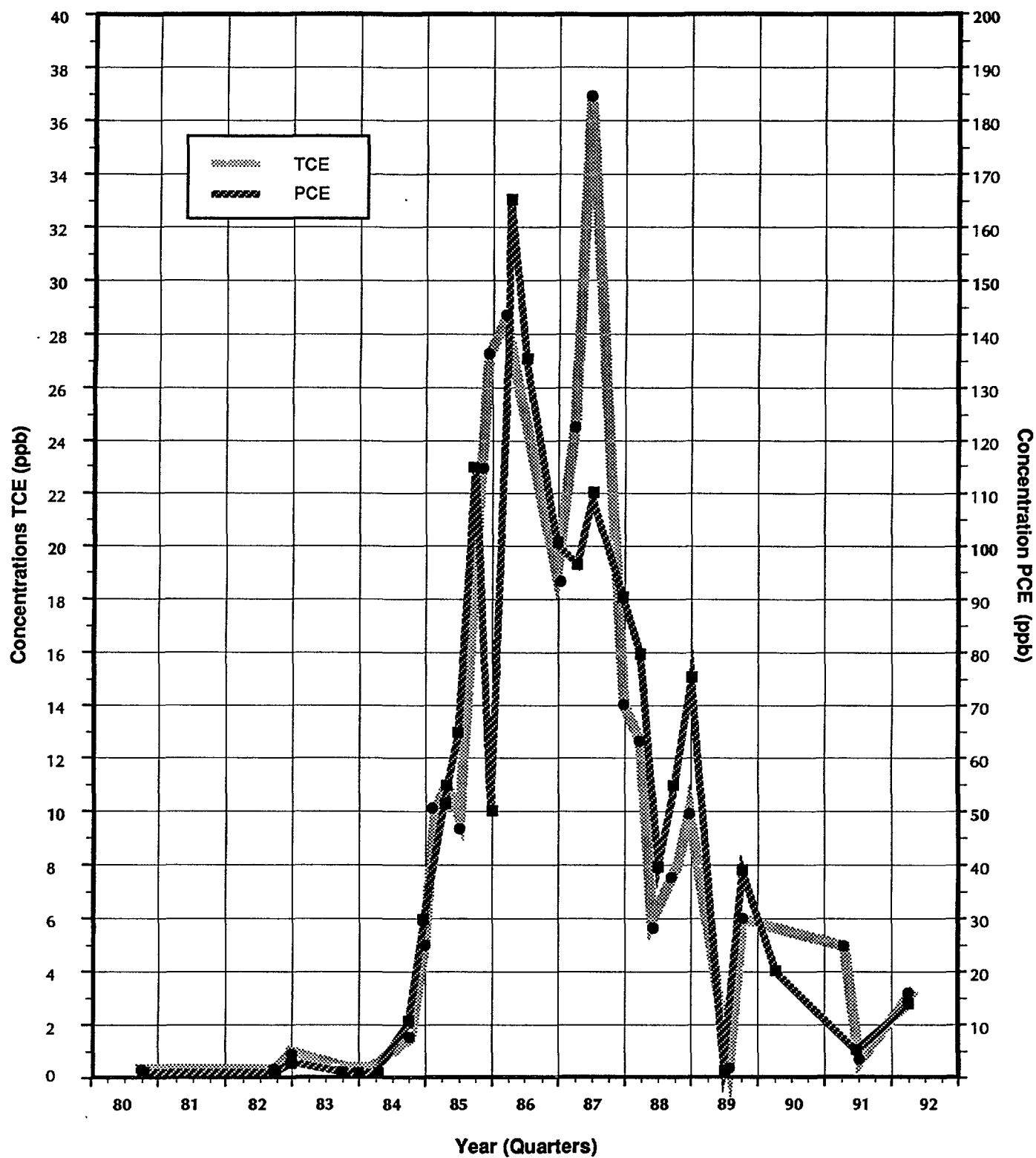


Figure 5-4  
Municipal Well Sampling Results for TCE & PCE  
Newmark Wellfield #3  
Newmark Operable Unit RI/FS Report



**Figure 5-5**  
**Municipal Well Sampling Results for TCE & PCE**  
**Newmark Wellfield #4**  
**Newmark Operable Unit RI/FS Report**

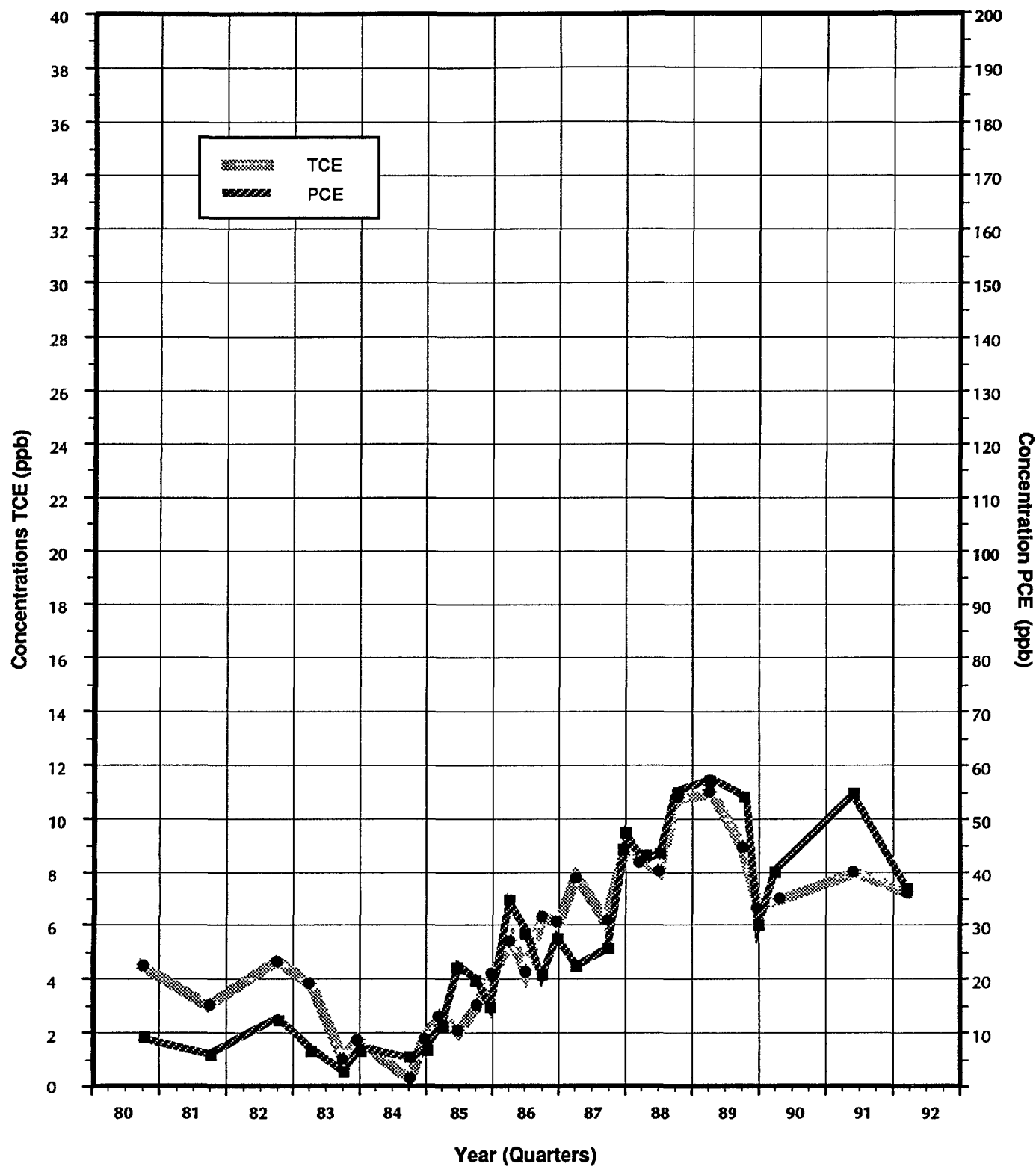
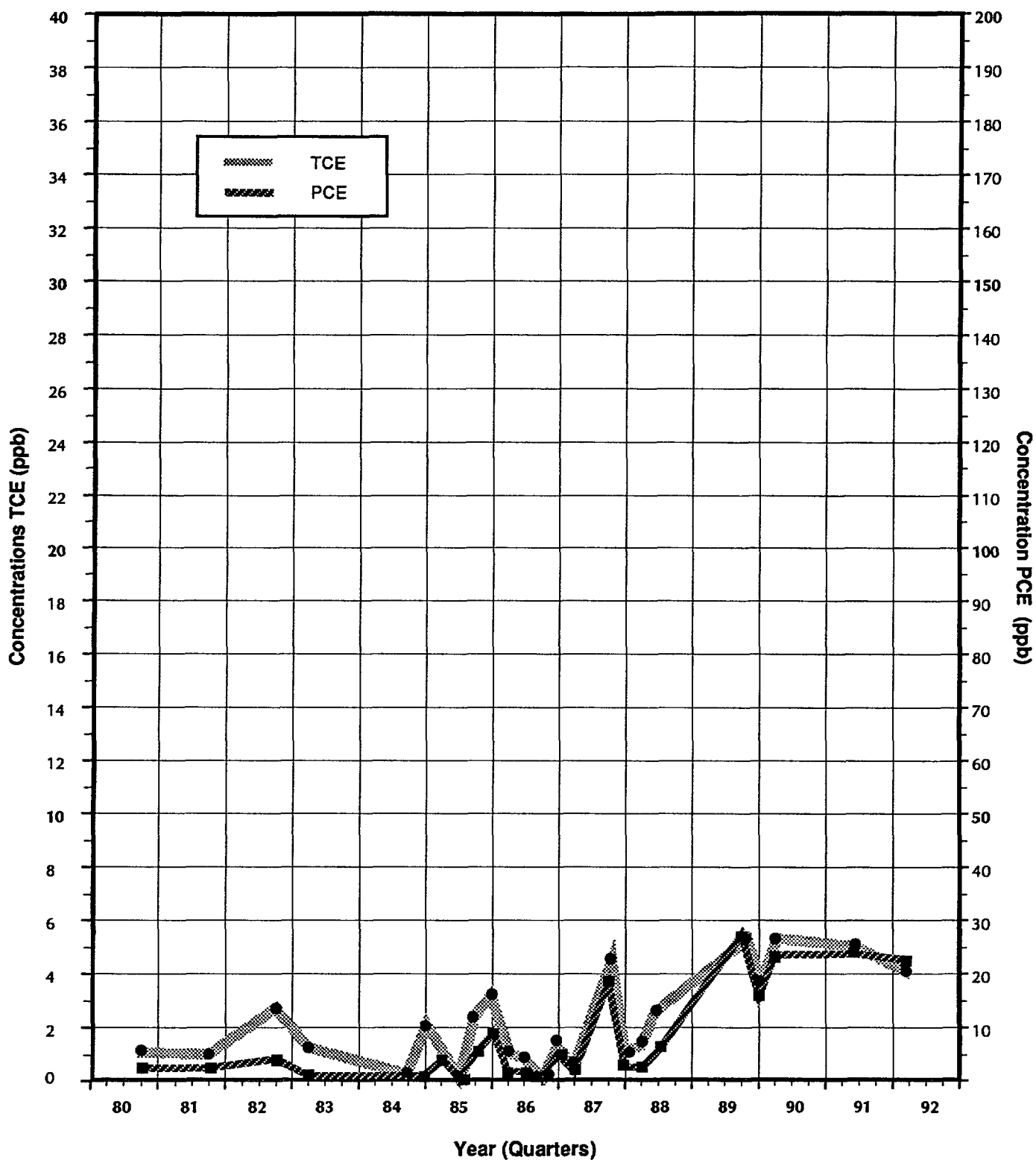


Figure 5-6  
Municipal Well Sampling Results for TCE & PCE  
Leroy  
Newmark Operable Unit RI/FS Report



**Figure 5-7**  
**Municipal Well Sampling Results for TCE & PCE**  
**Waterman Avenue**  
**Newmark Operable Unit RI/FS Report**



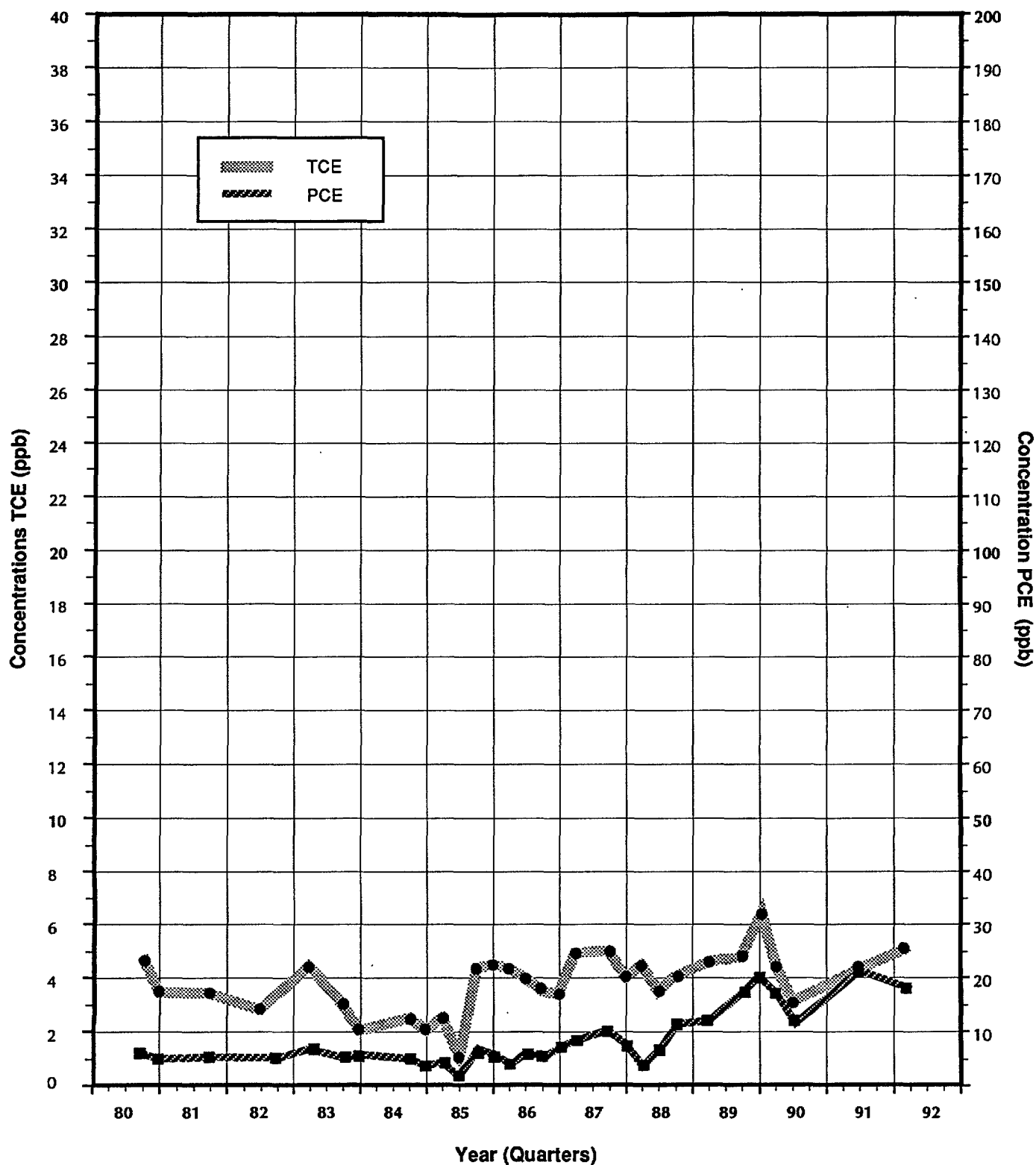
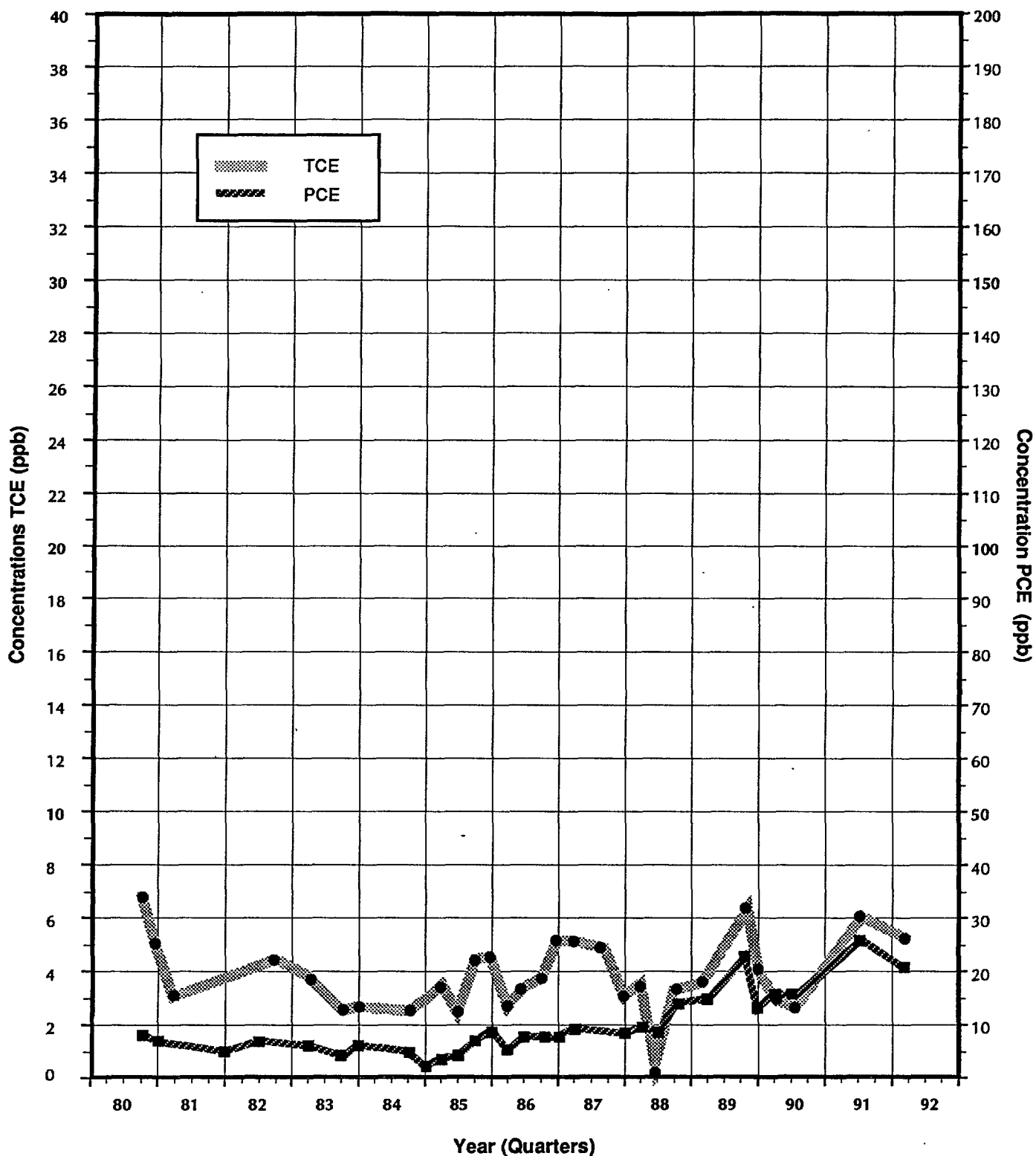


Figure 5-8  
Municipal Well Sampling Results for TCE & PCE  
30th Street and Mountain View  
Newmark Operable Unit RI/FS Report



**Figure 5-9**  
**Municipal Well Sampling Results for TCE & PCE**  
**31st Street and Mountain View**  
**Newmark Operable Unit RI/FS Report**

MW01 located east of the North E Street and 23rd Street wells and centrally within the plume had no detectable concentrations of volatile organics within any of the 10 vertically distributed sample ports. Chromium was detected at a level of 93.2  $\mu\text{g/L}$  in sample port located 960 feet bgs.

Further south and slightly west, the 27th Street, the North E Street, and 23rd Street wells had low concentrations of TCE and PCE. TCE was 0.2  $\mu\text{g/L}$ , 0.4  $\mu\text{g/L}$ , and non-detect, respectively, while PCE was detected at 0.5  $\mu\text{g/L}$ , 0.7  $\mu\text{g/L}$ , and 0.3  $\mu\text{g/L}$ , respectively. All quantities were estimated and used for qualitative purposes. The southern-most occurrence of contaminants was at the 17th Street and 16th Street wells. TCE was 2  $\mu\text{g/L}$  in each well and PCE was 3  $\mu\text{g/L}$  in each well. Both wells also had low concentrations of Freon 11 and Freon 12.

On the east side of the investigation area, the Lynwood, Perris Hill #2 and Gilbert Street wells had no detectable contamination. The boring log for the Perris Hill #2 well was not well documented. It was considerably shallower than the other wells in the southern half of the study area and appeared to be screened only above the confining clay layer. Therefore, it was ineffective in helping to define the plume and lower aquifer. The eastern plume edge was indicated to be between the Lynwood and Gilbert wells and the Waterman Avenue and Leroy, and 17th Street and 16th Street wells. To the south, the 10th and J Street, and 7th Street wells also had no detectable contamination indicating the southern edge of the plume is between these wells and the 17th and 16th Street wells.

Based upon the results of the above sampling, a map delineating the boundaries of the Newmark groundwater contamination plume was developed (see Figure 1-4). Section 7.0 presents a summary evaluation of these results.

### **5.3 VOLUMES AND MASS**

Using the areal extent of the Newmark plume as shown in Figure 1-4 and the aquifer thickness derived from the model input data (by subtracting the groundwater elevation from the bedrock elevation for each model cell, see Appendix J), it is estimated that 42,909,274,800  $\text{ft}^3$  of the aquifer is contained in the plume. Based upon sampling results of monitor wells MW02A and B through MW08A and B, it was assumed that only the lower one half of the aquifer is contaminated. Assuming a range for the aquifer

1 porosity of 20% to 40%, the volume of contaminated water was calculated to range from 4,297,727,480  
2 ft<sup>3</sup> to 8,595,454,960 ft<sup>3</sup>. Using the arithmetic mean of 23.23 ppb (see Table 1, Appendix P) for the  
3 concentration of volatile organic contaminants in the aquifer, the estimated mass of contaminants ranges  
4 from 6,200 lb to 12,400 lb. Applying an average value of 1.5 for the specific gravity of the  
5 contaminants, the estimated volume ranges from 500 gallons to 1,000 gallons.

## 6.0 CONTAMINANT FATE AND TRANSPORT

This section provides an analysis of the fate and transport of perchloroethylene (PCE) and trichloroethylene (TCE), the two chemical contaminants of concern in the Newmark study area environment. The analysis identifies the environmental media or compartment (i.e., water, air, soil, biota) potentially affected by contaminant migration and the possible extent of the contamination within each media. The results of this analysis will provide a basis for determining potentially exposed populations or environments and an estimation of the levels of exposure.

The fate and transport of chemical compounds released into the environment are influenced by the chemical and physical characteristics of the contaminants, their persistence in the environmental media, source characteristics, release mechanisms, and the transport mechanisms and dominant pathways of contaminant migration.

Although a screening-level evaluation of the fate and potential transport of contaminants within and between other media is presented in this section, the primary focus will be on the fate and transport of TCE and PCE in groundwater. The following subsections discuss the physical and chemical characteristics and environmental persistence of PCE and TCE; source characteristics and the affected environmental media; the transport mechanisms and dominant transport pathways; an analysis of the nature and extent of groundwater contamination based on the results of the RI and groundwater modeling; and a screening risk assessment.

### **6.1 CONTAMINANT CHARACTERISTICS AND ENVIRONMENTAL PERSISTENCE**

#### **6.1.1 Chemical and Physical Characteristics**

PCE and TCE are chlorinated aliphatic hydrocarbons belonging to a family of unsaturated hydrocarbons known as alkenes. Alkenes are distinguished by the presence of a carbon-carbon double bond, indicated

1 as C=C. At room temperature both PCE and TCE are colorless, volatile, nonflammable, dense liquids  
2 with characteristic odors that are mildly sweet and resemble chloroform. Although relatively insoluble  
3 in water, PCE and TCE are miscible with alcohol, ether, chloroform, and benzene (Merck 1989). The  
4 physical properties of PCE and TCE are provided in Table 6-1.

5 PCE is used as a solvent in a wide variety of industrial and commercial applications and products  
6 including dry cleaning, degreasing, paints and coatings, adhesives, and as a registered pesticide for  
7 controlling wasps and hornets (CARB 1991). TCE has been used in degreasing operations, polyvinyl  
8 chloride (PVC) production, adhesive formulations, painting and coating operations, as a refrigerant and  
9 heat exchange liquid (CARB 1990), and was also once used as an anesthetic.

10 To describe the persistence of common groundwater contaminants, an EPA groundwater supply survey  
11 of 466 randomly selected public groundwater supply systems detected one or more volatile organic  
12 chemicals (VOCs) in groundwater samples collected from 16.8 percent of small water systems and 28  
13 percent of large supply systems. The two VOCs most commonly present were PCE and TCE (EPA  
14 1987).

#### 15 **6.1.2 Contaminant Fate and Persistence**

##### 16 **Perchloroethylene (PCE)**

17 When released to surface soils, particularly dry soil, PCE is subject to fairly rapid evaporation due to  
18 various chemical parameters, such as its high vapor pressure and Henry's Law constant, and low soil  
19 adsorption ( $K_{oc}$ ). The importance of these parameters is discussed in Subsection 6.3.1. PCE exhibits  
20 low to medium mobility in soil but can percolate fairly rapidly through dry, sandy soil to reach  
21 underlying groundwater.

Table 6-1

## PHYSICAL PROPERTIES OF PCE AND TCE

Property	PCE	TCE	Reference
Synonyms	Tetrachloroethene (IUPAC), Perchloroethylene, Ethene, Tetrachloroethylene, Perk Ethylene Tetrachloride, Tetra Cap, Perclene	Trichloroethene (IUPAC) Ethylene Trichloride, Triclene, Trilene, Algylen, Chlorylen, Gemalgene, Trethylene, Trichloran	Weiss 1986, Keller 1992
Chemical Formula	$\text{Cl}_2\text{C} = \text{CCl}_2$	$\text{Cl}_2\text{C} = \text{CHCl}$	Merck 1989
CAS Registry Number®	127-18-14	79-01-6	Keller 1992
NIOSH RTECS Number	KX3850000	KX4550000	NIOSH 1990
Molecular Weight	165.85	131.40	Merck 1989
Boiling Point (760 mm Hg)	121°C	86.7°C	Merck 1989
Melting Point	-22°C	-84.8°C	Merck 1989
Water Solubility (20°C)	400 mg/L 150 mg/L	1000 mg/L 1100 mg/L	Lyman 1990 EPA 1986
Specific Gravity (20°C)	1.62	1.46	Merck 1989
Vapor Pressure (20 to 30°C)	17.8 mm Hg	57.9 mm Hg	EPA 1986
Henry's Law Constant (atm-m <sup>3</sup> /mol)	0.0259 0.0149 0.0083	0.00910 0.0103 0.01	EPA 1986 Howard 1990 Lyman 1990
Organic Carbon Partition Coefficient (K <sub>oc</sub> )	282.75 ml/g	147.48 ml/g	Hassett et al 1983*
Log Octanol/Water Partition Coefficient (Log K <sub>ow</sub> )	2.60	2.29	Vershueren 1983
Conversion Factor: Gas Phase (25°C, 760 mm Hg)	1 ppbv = 6.78 ug/m <sup>3</sup> 1 ug/m <sup>3</sup> = 0.15 ppbv	1 ppbv = 5.37 ug/m <sup>3</sup> 1 ug/m <sup>3</sup> = 0.19 ppbv	Clayton 1982
Diffusion Coefficient (30°C)	.07852 cm <sup>2</sup> /sec	.08606 cm <sup>2</sup> /sec	EPA 1988

IUPAC = International Union of Pure and Applied Chemistry (nomenclature system)

CAS = Chemical Abstracts Service Registry Number®

NIOSH RTECS = National Institute for Occupational Safety and Health Registry of Toxic Effects of Chemical Substances

\* Calculated from the relationship:  $\text{Log } K_{oc} = 0.909\text{Log } K_{ow} + 0.088$

1 Although stable under aerobic conditions, PCE can undergo slow biotransformation by reductive  
2 dechlorination under anaerobic methanogenic conditions through a process of transformation known as  
3 co-metabolism. The process is mediated by the presence of a primary substrate (e.g., methane) for  
4 energy and growth, and the conditions necessary for its production by acclimated microorganisms such  
5 as methane-producing anaerobes (methanogens) or sulfate-producing bacteria. The reaction involves a  
6 sequential reductive dehalogenation (e.g., PCE to TCE, TCE to the dichloroethylene isomers cis- and  
7 trans- 1,2 dichloroethylene, and finally to vinyl chloride). The mechanism consists of the chlorinated  
8 compounds accepting electrons from other organic compounds, or geologic material in the aquifer, and  
9 the subsequent release of chlorine ion ( $\text{Cl}^-$ ). The process is slow and normally requires long lag periods  
10 before active transformation begins (EPA 1987; Howard 1990). A more thorough discussion of the  
11 process is presented in Section 6.3.1. In general, the rates of the reaction tend to be higher for the more  
12 chlorinated compounds such as PCE and TCE.

13 The persistence and fate of PCE vapor in the atmosphere is predominantly affected by chemical removal  
14 mechanisms, consisting of ultraviolet catalysis, or photo-chemical reactions with atmospheric oxidants  
15 (hydroxyl  $[\text{OH}]$  radical, ozone  $[\text{O}_3]$ , or nitrate  $[\text{NO}_3]$  radical), principally the OH radical. The  
16 atmospheric lifetime of PCE is inversely proportional to the atmospheric OH radical concentration.  
17 Various investigators and smog chamber studies predicted that the products of PCE photo-oxidation were  
18 likely to include toxic species such as phosgene ( $\text{COCl}_2$ ), hydrogen chloride, and trichloroacetyl chloride  
19 (trichloroacetyl chloride can undergo further conversion to carbon tetrachloride). Based on some  
20 estimates, photo-oxidation of PCE could result in atmospheric phosgene levels in the low parts per billion  
21 volume (ppbv) range under adverse meteorological conditions and an estimated 0.5 moles of phosgene  
22 may be formed for each mole of PCE (CARB 1991).

23 At average atmospheric (i.e., tropospheric) temperature and OH concentration, the atmospheric lifetime  
24 of PCE is expected to be approximately 150 days (CARB 1991). Other estimates of PCE's persistence  
25 in the atmosphere range from a half-life of approximately 60 days to complete degradation in an hour  
26 (Howard 1990). Physical removal mechanisms (rain washout, dry deposition, adsorption on aerosols)  
27 are of negligible importance because of PCE's physical properties (e.g., polarity, solubility, adsorptivity,  
28 vapor pressure) and the long removal times associated with these mechanisms (CARB 1991).



When released to surface water, PCE is subject to rapid volatilization with an estimated half-life ranging from less than one day to several weeks. Biodegradation, bioconcentration in aquatic organisms or adsorption to sediments are not considered significant (Howard 1990).

#### Trichloroethylene (TCE)

TCE is highly volatile. When released to soil, some TCE will volatilize and transfer to the atmosphere. The liquid phase, being dense, with a low tendency to adsorb onto soil (i.e.,  $K_{oc}$ ), will percolate downward to underlying groundwater.

Biodegradation in surface water is extremely slow under most conditions. Some studies have noted significant aerobic biodegradation, while others found no biodegradation in screening or seawater studies (Howard 1990).

Anaerobic transformation, or biodegradation, studies using aquifer material known to support methanogenesis, resulted in the removal of 70 to 99 percent of the TCE after 40 weeks (Howard 1990). The reductive co-metabolic process, discussed previously for PCE, involves a slow sequential reductive dehalogenation to the dichloroethylene isomers and then to vinyl chloride. TCE, unlike PCE, may also undergo co-metabolic oxidative dehalogenation by methanotrophic cultures with the possible production of glyoxylic acid and dichloroacetic acid intermediates (McCarty 1988).

The persistence of TCE in the atmosphere is predominantly affected by removal through photo-chemical reactions with highly reactive radicals (e.g., hydroxyl [OH] radical, ozone [O<sub>3</sub>], or nitrate [NO<sub>3</sub>] radical). The principal mechanism involves reactions with OH radicals during daylight hours with the formation of formyl chloride, phosgene, and, possibly, dichloroacetyl chloride (CARB 1990). Ozone and NO<sub>3</sub> radical reactions take too long to compete with the OH radical reaction and, therefore, are of minor importance. TCE is moderately persistent, with an atmospheric lifetime of 4 to 15 days (CARB 1990; Howard 1990). Physical removal mechanisms (rain washout, dry deposition, adsorption on aerosols) are considered negligible factors influencing its atmospheric persistence.

When released to surface water, TCE is subject to rapid volatilization with an estimated half-life ranging

from less than one day to several weeks. Biodegradation, bioconcentration in aquatic organisms or adsorption to sediments are not considered significant (Howard 1990).

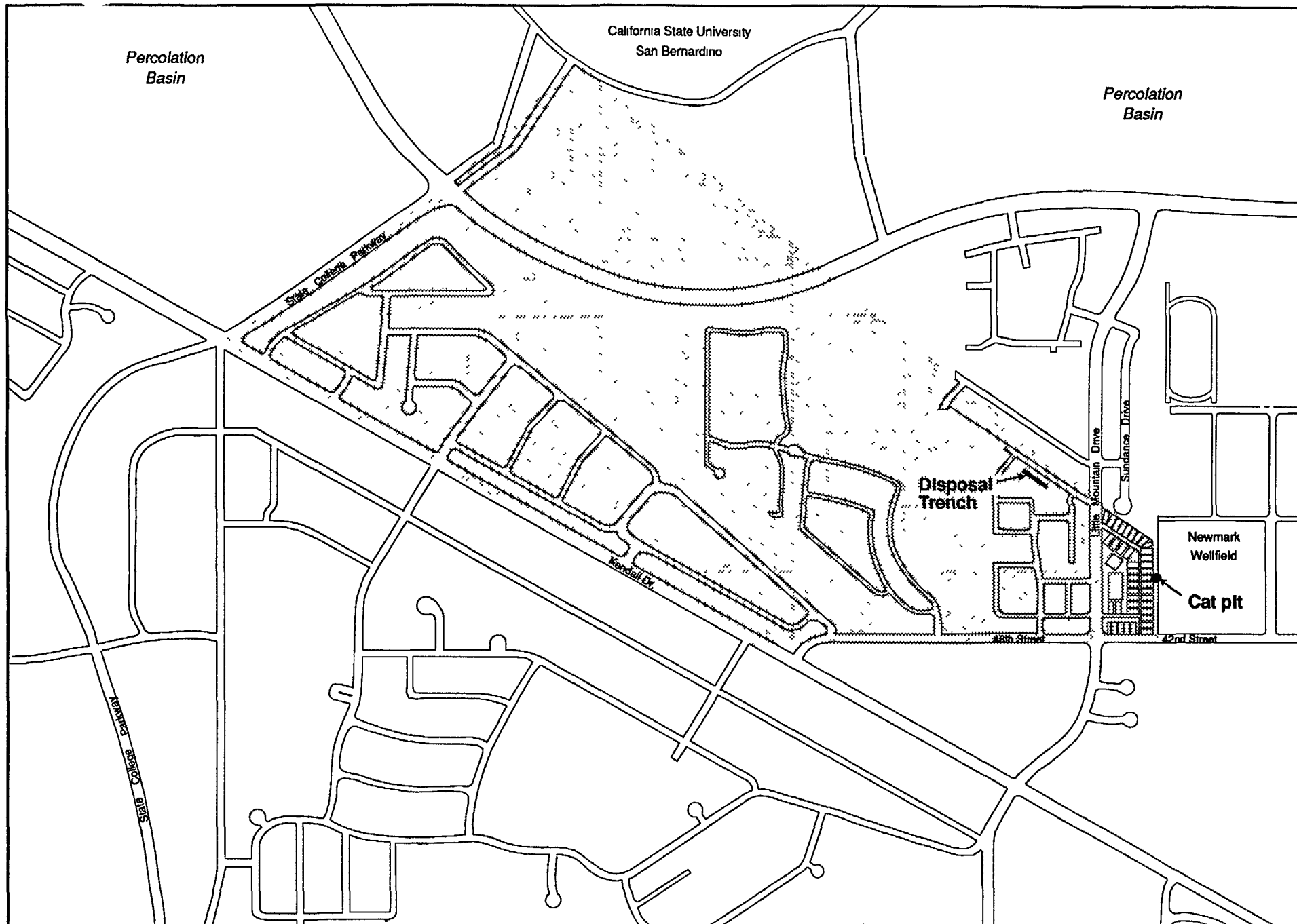
## **6.2 SOURCE CHARACTERISTICS AND AFFECTED ENVIRONMENTAL MEDIA**

This subsection discusses the characteristics of the suspected source area and probable nature of the releases, and describes the distribution of the contaminants in the affected environmental media.

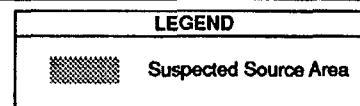
### **6.2.1 Source Characteristics**

The groundwater contamination, which is the focus of this RI, is believed to be the result of unauthorized, surreptitious discharges, as well as liquid waste storage, leaks, spills, or disposal practices occurring at or in the vicinity of the San Bernardino Airport during its operation and following its closure in 1958. Chlorinated solvents such as PCE and TCE were commonly used as degreasers and were probably spilled or discharged directly onto the ground, or into unlined sumps or pits in the form of aqueous wastes or concentrated liquids. Record searches and reviews of aerial photographs have identified two suspected sources, the Cat pit and disposal trench. The locations of these two suspected sources are shown in Figure 6-1.

Sampling results from MW03 indicated that contaminants existed upgradient of the Cat pit. To aid in locating the source, three additional monitoring wells (MW06, MW07, and MW08) were installed farther upgradient. MW06, installed up- and cross-gradient, produced no TCE or PCE contaminants; however, MW07 and MW08 indicated TCE and PCE contamination. These results led URS to believe the source of contamination is further upgradient of the originally suspected Cat pit.



**Figure 6-1**  
**Suspected Source Area**  
**Newmark Operable Unit RI/FS Report**

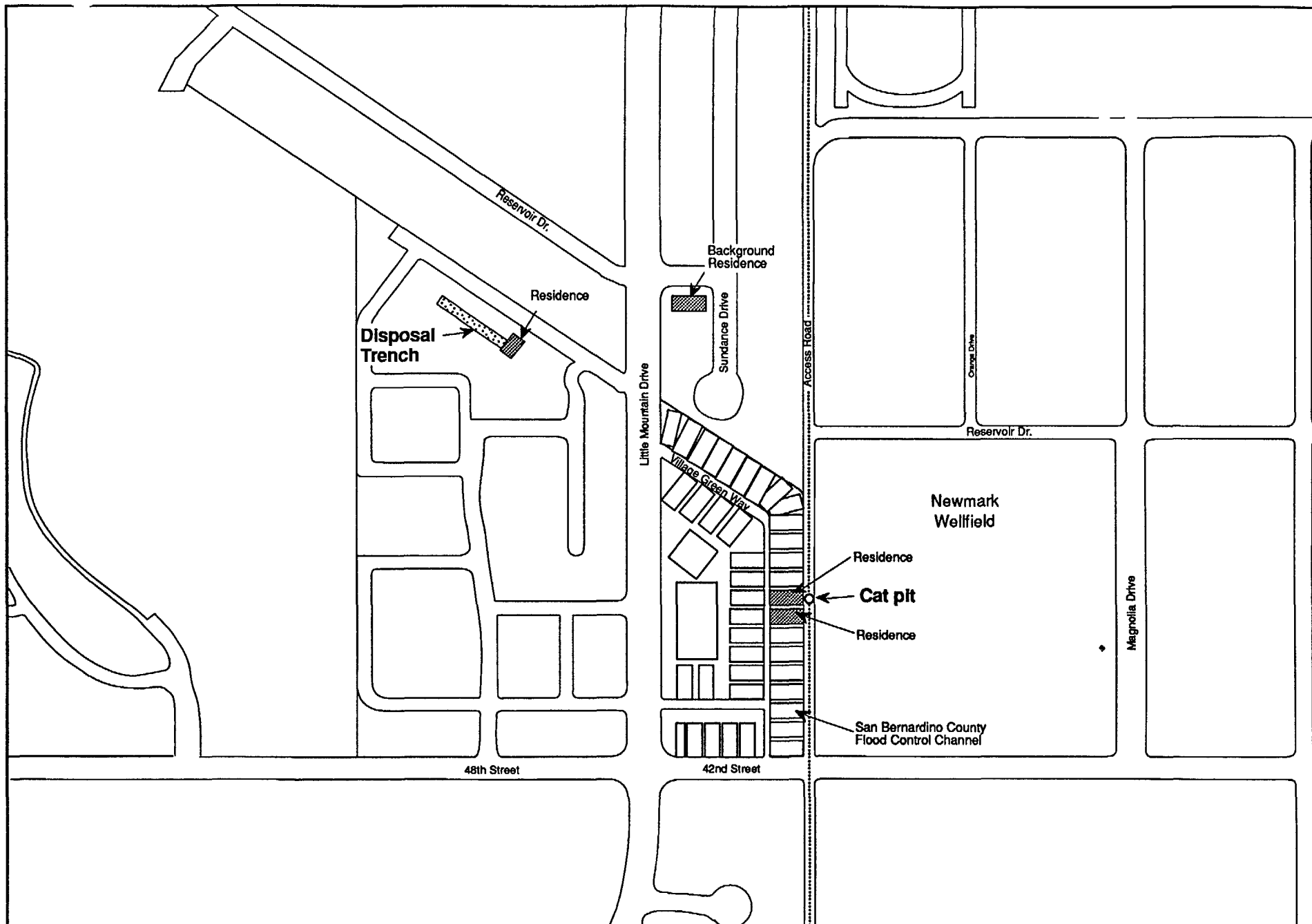


Not to Scale

1 Based on the qualitative and quantitative interpretation of the data collected during this RI, as well as the  
2 results of previous investigations, the media of importance consists principally of the contaminated  
3 groundwater plume, known as the Newmark plume, underlying the investigation area. There is no  
4 current evidence of residual contamination in surface soils or the vadose zone underlying the suspected  
5 source area of the former San Bernardino Airport. Furthermore, there is no evidence of any residual  
6 or continuing sources of contamination in the suspected source area, including waste piles, surface  
7 impoundments (lagoons, ponds, pits etc.), buried wastes (e.g., leaking drums, containers, tanks, sumps,  
8 pipelines etc.). However, these findings do not preclude the existence of other sources outside of the  
9 suspected source area that may be contributing to the groundwater contamination. Nevertheless, within  
10 the limits of the data generated during this focused RI, the principal environmental pathway of concern  
11 is the contaminated groundwater plume.

12 The analysis of soil cores collected at different depths during the installation of monitor wells (MW02  
13 through MW06) in the suspected source area (see Appendices C and F), and a soil gas survey conducted  
14 in the area of the former disposal trench (see Appendix L), did not find PCE, TCE or other VOCs in  
15 the vadose zone at detectable levels. Consequently, airborne emissions consisting of contaminated  
16 fugitive dust (i.e., contaminated soil particles) from surface soils, or volatile releases of sorbed  
17 contaminants from the unsaturated soils underlying the suspected source area are not considered potential  
18 transport pathways.

19 Furthermore, indoor air samples collected from three residences located within the suspected source area  
20 failed to demonstrate possible diffusive flux of PCE or TCE through the subsurface soils (vadose and  
21 saturated zone) into the indoor air of residences overlying the suspected source area. The locations of  
22 these residences are depicted in Figure 6-2. Although the analytical data indicated the presence of PCE  
23 and TCE in all but one air sample, the results were consistent with anticipated background concentrations  
24 determined during previous regional studies. The indoor air sampling activities are discussed further  
25 in Section 6.4 and a full report of the protocols and analytical results is included as Appendix K.



Not to Scale

Figure 6-2  
 Suspected Source Area Indoor Air Sampling Locations  
 Newmark Operable Unit RI/FS Report

## 6.2.2 Affected Environmental Media

Substances released at or slightly below land surface enter groundwater through percolation or direct migration. Direct migration can occur through leakage from sources lying within the saturated zone (e.g., storage tanks, pipelines, wells). Dry, soluble contaminants dissolved in precipitation, runoff, or applied water can migrate through percolation into the soil. The rate of movement depends on the water recharge rates (e.g., infiltration of rainwater through a contaminated soil zone) and contaminant solubility. Liquid organic contaminants such as PCE and TCE can percolate directly into soils. Figure 6-3 provides a simplified schematic of a TCE or PCE release. The percolating liquid or leachate continues to migrate downward into the saturated zone then spreads vertically and horizontally following the pattern of groundwater flow. Additionally, groundwater contamination can result from hydraulic mixing, or interaquifer exchange, with a contaminated aquifer or through groundwater recharge from a contaminated surface water body (EPA 1987).

Organic liquids of moderate to low solubilities such as PCE (150-400 mg/L) and TCE (1000-1100 mg/L) can contaminate as much as 10,000 times their own volume, up to 100 percent of their solubilities. The concentrations of these contaminants in groundwater, however, are only rarely close to their solubility limits, even when their solubilities are increased by the presence of other solvents or when they are present in the aquifer as a nonaqueous phase liquid (NAPL). The concentrations observed in the environment are generally an order of magnitude lower than the contaminants solubility in water. This is due to dilution of the contaminant through dispersion and spreading in the groundwater. Consequently, numerous or continuous small spills or leaks of tens of gallons of solvent that may have been considered insignificant at the time could constitute a significant contaminant source if the organic liquid reached the groundwater (Mackay et al. 1985). A more detailed discussion of the factors influencing contaminant movement is provided in Section 6.3.

The volume of groundwater that could be contaminated by an organic NAPL layer is substantial. In addition, the temporal extent of the contamination would be quite large since substantial time would have to pass before the flowing groundwater could exhaust the supply of the contaminant(s) contained in the NAPL layer.